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Wireless Traffic Light Controller for Emergency Vehicle through XBee and Basic Stamp Microcontroller

R.Hussin*, R.C.Ismail, E.Murrali, A.Kamarudin

School of Microelectronic Engineering,
University Malaysia Perlis (UniMAP),
Pauh Putra Campus
02600 Pauh
Perlis, Malaysia.
Email: shidee@unimap.edu.my

Abstract

The existing traffic light systems are unable to detect the presence of emergency vehicles on the road, especially in the emergency situation. The delay cause due to this situation can affect the life of the person in need of the emergency vehicles while delivering ther best service to the society. A wireless traffic light controller can resolve this problem. With a certain operating range (80m-1500m) the receiver and transmitter can correspond to each other to enable green light on the path of the travelling emergency vehicles. A simple approach using this method is done by using two wireless X-Bee modules, Basic Stamp Microcontroller and a Digital Compass. Upon using this system, the delay caused waiting for the green light can be reduced. This reduction in delay can increase the efficiency of the emergency vehicles and have a better potential to safe the life of person in need of the emergency vehicles service.

Keywords: Emergency vehicles, life, XBee, Basic Stamp, Digital compass, efficiency.

Nomenclature

CA	collision avoidance
CSMA	carrier sense multiple access
EEPROM	electronically erasable programmable read only memory
GPS	global positioning system
LR-WPAN	low rate wireless personal area network
PIC	peripheral interface controller
RAM	random access memory
ROM	read only memory
USB	universal serial bus

1. Introduction

Intersections and junctions are the areas with most conflicts among emergency vehicles and other vehicles due to the entering and crossing movements. The existing traffic light system in our country is not safe enough for the usage of emergency vehicles. There were no sensors installed yet to detect the presence and the approaching angle of the emergency vehicles, siren itself is not sufficient to avoid collisions in intersections and junctions for the emergency vehicles. Even with

* Corresponding author. Tel.: +6049885555; fax: +6049885510
E-mail address: shidee@unimap.edu.my

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improved intersection design and more sophisticated applications of traffic engineering measures, the annual toll of human loss due to the conflict caused by the traffic is still hasn't changed. It is necessary to implement a sensor which can detect the presence of emergency vehicle and avoiding conflict during the presence of it.

The advancing phase of Wireless Sensor Network (WSN) has made it possible to be analysed and to incorporate the application into the existing traffic light system in Malaysia. Such implementation has the potential to be deployed in a very short time and can be used for both monitoring and controlling the traffic [1]. Experiments in [2] found that wireless network offers much greater flexibility and more reliable.

Implementing a demonstration project comprise of basic stamp microcontrollers, wireless X-Bee modules and a digital compass to mimic the scenario of using this wireless sensor network to increase the efficiency and safety of the emergency vehicles and most importantly to avoid any traffic conflict during the incoming of emergency vehicles was conducted.

2. Hardware Environment

The hardware environment for this research paper consists of Parallax, Inc.'s BASIC Stamp® 2 modules, X-Bee wireless modules and Honeywell HMC6352 digital compass module. Upon using all this materials, a transmitter and a receiver circuit will be build. The microcontrollers which interface with both X-Bee and digital compass will act as the transmitter circuit, where else the microcontroller which interface with just the X-Bee module will act as the receiver circuit.

2.1. Microcontrollers

Microcontrollers are frequently used device in embedded computing in which the application varies from computing, calculating, smart decision-making capabilities, and processes the data. Most of the electrical/electronic device, sensors and high-tech gadget can be easily interface and interact with microcontrollers to automate a system structure. For this research BS2p40 and BS2pe are used.

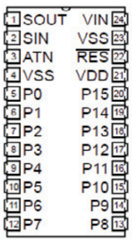


Figure 1-1: BS2pe

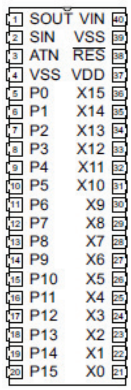


Figure 1-2: BS2p40

The BS2pe microcontroller has a 24-pin Dual Inline Package (DIP) and 16 of them are used for I/O interface [3]. The brain for the chip is Microchip Inc.'s PIC 16C57. Unlike from BS2p40, it is just the extra auxiliary 16 I/O pin option. Each pin can source (supply) a maximum current of 40mA and sink (draw) a maximum current of 50mA. A range of 6-14V direct current (VDC) power supply is sufficient to turn on BS2, because a voltage regulator embedded inside it, provides a steady 5VDC supply to the BS2 such that the high voltage will not damage the IC. BS2 has 2KB Electronically Erasable Programmable ROM (EEPROM), and a little amount of RAM and is programmed using PBasic language; the instruction set that is permanently stored on the BS2 ROM. The user-define program is downloaded into the EEPROM from a PC through a DB-9 serial cable connection between the PC and the microcontroller. The excess EEPROM can be used for long term data storage. See [3] for more details on BS2 hardware features.

2.2. XBee

X-Bee module is a device use to communicate via wireless network, it utilizes the IEEE 802.15.4 protocol which implements the entire features list below as to ensure data delivery and integrity:

- Media Access: A special feature to make certain two network nodes do not transmit at the same time causing data collisions and errors in communication.

- Addressing: A technique to ensure only the intended node uses the receive data, allowing data to be sent from one point to another point, or point to multi-point by sending a broadcast meant for all nodes on the network.

- Error Detection: A way to validate data received at the node correctly.

- Acknowledgements & Retries: A way to notify the transmitting node that the data was delivered successfully. Lacking this, several retries may be performed in an effort to deliver the data.

Such protocol is known as the Low-Rate, Wireless Personal Area Network (LR-WPAN). It provides up to 250kbps of data throughput between nodes on a CSMA/CA network.

The X-Bee modules come in a several versions but all have similar pinouts as shown in the Figure 1-3. Difference between X-Bee versions includes the power output, antenna style, operating frequency and networking abilities. The X-Bee has many other features for use in a WSN beyond its networking ability. See [4] for more details on X-Bee hardware features.

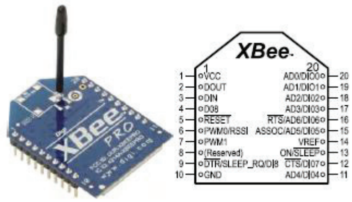


Figure 1-3:X-Bee Pro modules and Pinouts

2.3. Digital Compass

The HMC6352 digital compass module as shown in Figure1-4, combines 2-axis magneto-resistive sensors with the essential analogue, digital, microprocessor and algorithms required for heading computation. It provides the heading angle of the compass and includes internal calibration algorithms within its firmware for calibration purpose.

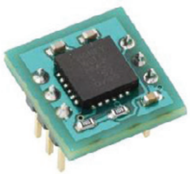


Figure 1-4: HMC6352 Compass

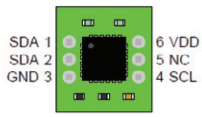


Figure 1-5: HMC6352 Pinouts

Temperature compensation and calibration are built in, as well as protection against stray magnetic fields. It operates with VDC supply ranging from (2.7-5.0V), has digital output to nearest 0.1 degree, low current consumption (typically 1µA in standby mode, 1mA full operation at 3VDC). It can be applied to provide headings when GPS signal cannot be used, also used as a reference for orienting gyroscope. It has 6 pinouts as shown in the Figure 1-5. See [5] for more details of HMC6352.

3. Software Environment

Serial communication is a type of protocol used for data communication between two or more devices, it uses a data port to send and receive data in serial manner. Programming two or more devices to communicate serially requires that the devices operate at the same communication rates known as the baud rate, for this research all the communication baud rate is fixed to be at 9600Bps. See [6] for more details on serial communications. For this research there are two main softwares being used to enhance a better understanding on what's our microcontroller is doing. The softwares used are BASIC Stamp Editor v2.5.2 to program the BASIC Stamp microcontroller and the X-CTU software to view the data being transmitted/received wirelessly.

3.1. PBasic Program

The PBasic programming language used by the BS2 is a Basic C-like language developed by Parallax, Inc. The BS2 executes certain task specific commands. Some commands that are used to design the module are analysed.

```
DEBUG HOME, "Heading = ", DEC Heading / 10, " degrees" ' Print aingle
```

Figure 1-6: DEBUG command

The debug command as shown in Figure1-6 is important to our discussion since it execute the serial communication between the BS2, X-Bee and PC. The debug command instructs the BS2 to display a string of data on the PC. The string can be either a simple message, or a data string at the debug terminal as in Figure1-7. For this instruction the string would display the heading angle as shown in Figure1-8. This heading angle is the output from the digital compass connected to the BS2. The BS2 can display data in one of three formats, binary, decimal, or hexadecimal. The data that will be displayed can be specified to be *bin* prefix for binary*, dec* prefix for decimal*,* and *hex* prefix for heaxadecimal.

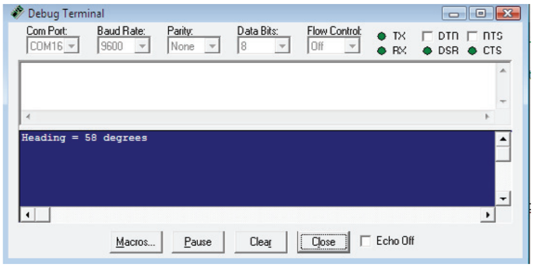


Figure 1-7: DEBUG terminal

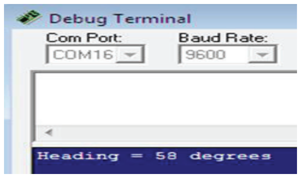


Figure 1-8: Heading angle

Serial communication with a BS2 is accomplished using the following two commands.

```
SERIN:serinRpin,(\Fpin),baudmode,{Plabel},{Timeout,Tlabel}, [InputData]
```

Figure 1-9: SERIN command

The serin command as shown in Figure 1-9 is used to import data from another device, the X-Bee in this case to the BS2. The serin command might have 3-6 arguments, depends on the type of application that the command going to be used. The required arguments are the Rpin, in which the data will be received, baudmode, which specifies the rate of data transfer at which the devices communicate, and InputData, which instructs BS2 about where to store the received data. In addition, the serin command can take on an optional Fpin argument and Plabel argument which is used to oversees flow control of the data and when the baudmode is set to seven bits and even parity. This argument instructs the BS2 on where it should go in case of a parity error. Finally, the serin command can take on the arguments of Timeout in conjunction with Tlabel. The Timeout argument sets the duration for which the BS2 must wait for incoming data. Tlabel instructs the BS2 on where it must go in the event of a timeout. With the example of command to receive the data, now the BS2 will have the heading angle data from the digital compass which is received by the X-Bee module.

```
SEROUT:seroutTpin,(\Fpin),baudmode,{Pace},{Timeout,Tlabel}, [OutputData]
```

Figure 1-10: SEROUT command

The serout command as shown in Figure1-10 is used to export data from the BS2 to another device, in this case it used by the BS2 to X-Bee. The serout command take 3-6 arguments. The essential three arguments are Tpin, baudmode and the OutputData which are used for the data transmission pin, specifies the speed and configuration at which the two devices communicate, and instructs the BS2 on what data to export. Additional three arguments, can be modified in one of two ways. One configuration uses the additional arguments of Fpin, a pin that will monitor the flow of data, Timeout in conjunction with Tlabel. The Timeout argument instructs the BS2 on how long it must wait for Fpin to give send permission. Tlabel instructs the BS2 on where it must go in the event of a timeout. An alternate configuration uses the Pace argument to set the time between consecutive transmission of data. With this command, now the BS2 can transmit the data from the digital compass to the X-Bee module through the BS2.

3.2 X-CTU software

The X-CTU software is a software used to indicate the data that either being transmitted/received by the X-Bee module. This process is initiated by connecting the X-Bee module to the PC using a USB cable. The X-CTU software interface is as shown in Figure 1-11.

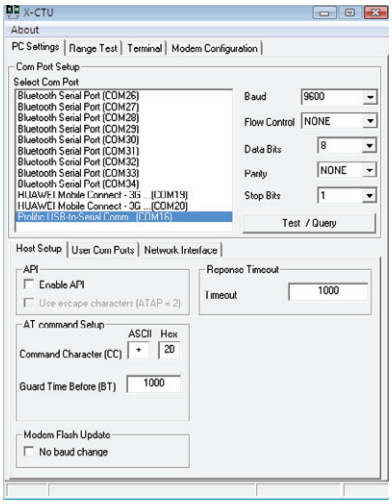


Figure 1-11: X-CTU software com port selection

Figure 1-12: X-CTU test query response

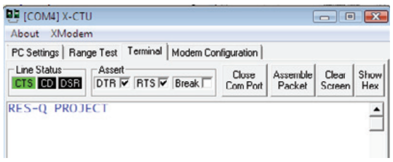


Figure 1-13: X-CTU terminal

Using X-CTU, the configuration of the X-Bee may be modified and the firmware upgraded. Through the software, the X-Bee configuration may be read, changed and written for updates. The X-Bee may also be configured through any terminal interface or from the controller by sending the correct character sequences.

4. Circuit Design

The circuit design for this research is divided into two parts namely the transmitter and the receiver circuit. The interconnection for the transmitter circuit is shown as in Figure1-14 and for the receiver circuit, it is shown in the Figure1-15.

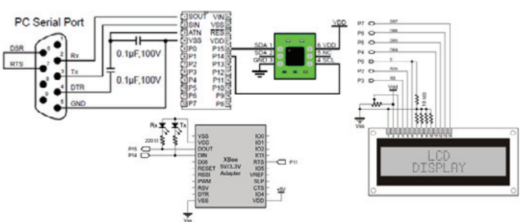


Figure 1-14: Transmitter circuit

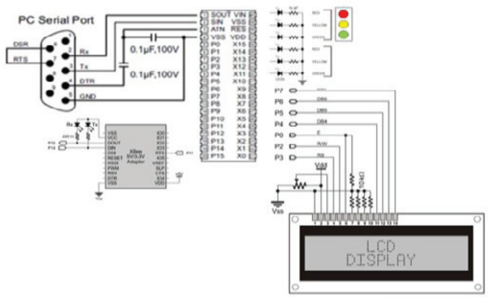


Figure 1-15: Receiver circuit

5. Circuit Operation

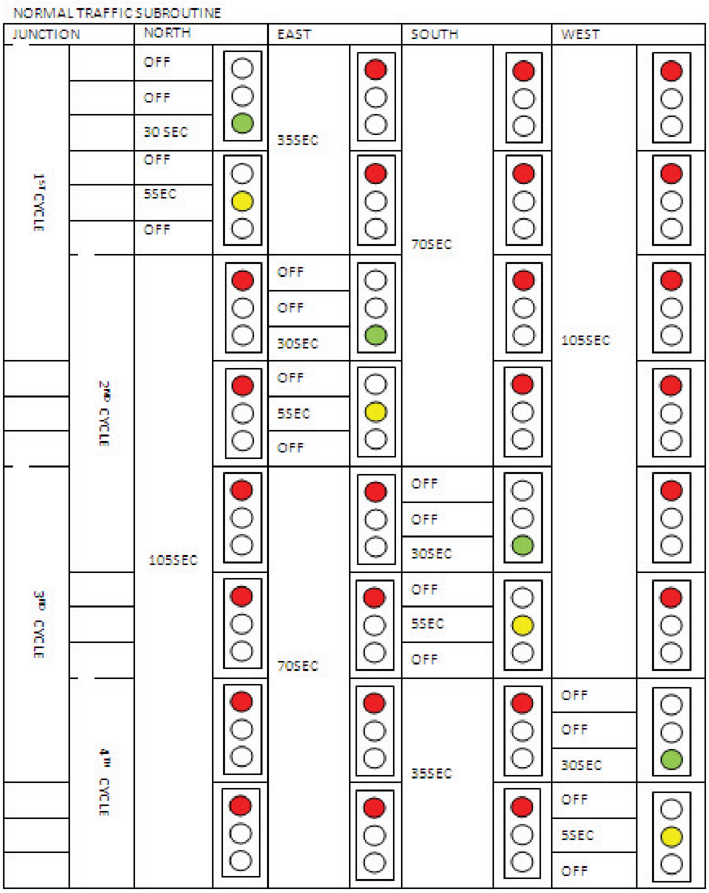
The operation of the circuit depends on the push button in the emergency vehicle module (transmitter). When this push button is pressed, it indicates the emergency situation where the siren and the wireless module inside it will be turn ON simultaneously. The data being transmitted would be the heading direction angle of the emergency vehicle, if it is heading North then the South junction lane will be turn to Green light. The receiver will receive the data an enable green light along its path. The path North, East, South or West will turn from the variation of the angle as listed in the Table1.

Table1

HEADING ANGLE (DEGREE)	DIRECTION	JUNCTION TURN TO GREEN
316° - 45°	NORTH	SOUTH
46° - 135°	EAST	WEST
136° - 225°	SOUTH	NORTH
226° - 315°	WEST	EAST

The operation on this system will be determine by a push button on the transmitter circuit to transmit the emergency signal, if the signal is not turn on the normal operating function would be as in the Table2.

Table 2



6. Conclusion

Traffic light controller is the most important system in determining the safety of vehicles at intersections and junctions. Wireless sensor network can further increase the safety level of this traffic light. Throughout this research, the influence of integrating Basic Stamp microcontroller X-Bee modules can provide such an applicable WSN in the real traffic scenario. The influence of PBasic language on the effect of wireless data transmission particularly on the serial communication is further analysed and used to improve the quality of wireless communication. A proper and detailed instruction sets need to be outlined before commencing it for implementation. In this research, the capability of using wireless sensor is proved to sense the presence of emergency vehicle, hence give priority for them to go through their lane without worrying of collision because there will not be any traffic conflict along the path it travels. The aim of this project, which is to reduce the delay caused by the conventional traffic light system and increase the efficiency of the emergency vehicle is achieved. As the continuation of this project, attaching together a speedometer to the transmitter circuit to transmit the approaching speed and distance of the vehicle from the receiver can further optimize the traffic flow. Through some Artificial Intelligence (AI) techniques this will be done to ensure a safer intersections and junctions.

References

[1] Sing Yiu Cheung, Sinem Coleri, Baris Dundar, Sumitra Ganesh, Chin-Woo Tan, and Pravin Varaiya. Traffic measurement and vehicle Classification with a single magnetic sensor. Technical report, 84 th Annual Meeting, Transportation Research Board, 2005.

[2] Sing Yiu-Cheung, Sinem C. Ergen, and Pravin Varaiya. Traffic surveillance with wireless magnetic sensors. *ITS World Congress*, November2005.

[3] Basic Stamp 2 microcontrollers comparisons. Retrieved April 28, 2012 from http://www.parallax.com/detail.asp?product_id=BS2-IC website of Parallax. Inc. developer and distributor of Basic Stamp 2 microcontroller.

[4] Basic Stamp 2 microcontrollers. Retrieved April 13, 2012 from http://www.parallax.com/go/XBee website of Parallax. Inc. developer and distributor of Basic Stamp 2 microcontroller.

[5] Digital Compass HMC6352 (2006). Retrieved March 23, 2012 from http://www.sparkfun.com/datasheets/Components/HM C6352.pdf Form #900307 Rev D January 2006 ©2006 Honeywell International Inc.

[6] Basic Stamp programming manual (2008). Retrieved March 31, 2012 from http://www.parallax.com/dl/docs/prod/stamps/Basic Stamp *Basic Stamp Programming Manual,* v2.0c.